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~~ATOMIC WEAPONRY~~  
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HISTORY OF THE MK 5 WARHEAD (u)

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TIMETABLE OF MK 5 WARHEAD EVENTS

1900 Rocketry has beginnings as a science.

1929 Nazis start intensive study of guided missiles.

Early 1946 Rand Project founded. Early rocket-study work.

3-46 Army Air Forces institute work on Project MASTIFF, an experimental missile.

1-10-47 Early proposals for atomic warheads.

4-29-49 Division of Military Application requests views of Military Liaison Committee on missile/atomic warhead work.

1-27-50 Detailed studies of missile/atomic warheads approved.

6-21-50 Sandia Weapons Development Board accepts cognizance of missile/warhead work.

10-1-50 Department 1270 established at Sandia for missile/warhead design.

9-11-51 Military characteristics for XW-5 Warhead issued.

8-53 Mk 5 Mod 0 Warhead design released.

7-54 Mk 5 Mod 0 Warhead enters production.

Mk 5/REGULUS

1-50 Project approved by Secretary of Defense.

1-51 Missile/warhead placed in active design.

9-10-51 XW-5/REGULUS Ad Hoc Working Group meets.

8-18-52 RAM Project initiated.

10-28-52 Flight tests of XW-5/REGULUS started.

9-53 Design release of Mk 5/REGULUS.

4-54 Initial production of Mk 5/REGULUS.

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Mk 5/MATADOR

Early 1950 Missile considered for marriage with atomic warhead.  
12-18-50 Project approved by Joint Chiefs of Staff.  
10-3-51 XW-5/MATADOR Ad Hoc Working Group formed.  
Early 1952 Missile flight problems develop.  
Spring 1954 Black Swan program initiated.  
Early 1956 Continuing missile difficulties cause cancellation of program.

Mk 5/RASCAL

3-16-50 Military Liaison Committee proposes XW-5/RASCAL marriage program.  
8-20-50 Sandia Weapons Development Board authorizes program activity.  
11-7-51 XW-5/RASCAL Ad Hoc Working Group formed.  
1-53 Fuzing responsibility for project assigned to Air Force.  
Fall 1953 Missile flight problems develop.  
3-56 Program canceled in favor of Mk 27 Warhead.

Mk 5/RIGEL

8-28-50 Field Command informs Sandia concerning project.  
4-25-51 Missile characteristics issued.  
9-30-53 Program canceled.

XW-5/HERMES

3-13-51 Army suggests use of HERMES proximity fuzes on atomic warhead installations.  
5-21-51 HERMES temporarily deleted from program.

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5-27-52 HERMES reinstated; to be mated to Mk 5 Warhead.  
10-16-52 Budget cuts delay program.  
9-18-53 Program terminated.

Mk 5/F-101

4-9-53 Program established by Joint Chiefs of Staff.  
8-53 XW-5/F-101 Joint Project Group formed.  
3-56 Program canceled.

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With the approach of World War II, both the German and Russian rocket programs became enveloped in secrecy. The next reliable information was received by the West when the Nazi V-1's (and later the V-2's) began to bombard London. This effort was not small. Dr. Walter R. Dornberger, who was in charge of the V-2 program and retained meticulous records of the activity, disclosed after the war that 5085 V-2's were build and 3578 launched.<sup>1</sup> After the end of the European phase of World War II, many German rocketry experts were captured by the Russians, forcibly removed to Soviet territory along with the tools and equipment of their trade, and their lore and experience added to that of the Soviets.

The United States had used small solid-propellant rockets in the Pacific phase of the war, with ship-launched rockets being employed as "softening-up" devices prior to Marine landings on Japanese-held islands, and hand-held Bazookas being used in the attack of enemy strongpoints. No heavy boosters or liquid-motor rockets had been developed, however, and the field of use of these devices was felt to be small.

Postwar experimentation at the White Sands Proving Ground in New Mexico with a captured German V-2 brought the United States to the realization that this liquid-motor device, capable of a velocity of 3600 miles per hour and a range of 100 miles, was worth developing. The Air Force established the Rand (research and development) Project under the aegis of Douglas Aircraft Company in early 1946, and the first study produced by this group described a satellite vehicle using liquid fuel and multistage rockets. Dr. Theodore von Karman, one of the organizers of the Rand Project, subsequently surveyed the state of the art in Europe and came to the conclusion that the best method of increasing the range of the V-2 was to provide a set of wings for the missile. The United States elected to follow this course, which led to consideration of pilotless bombers flying at relatively low altitudes, and development of air-breathing missiles rather than pure rockets, which were self-contained and could operate outside the atmosphere.

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The success of the Germans in developing the V-missiles and the later appearance of the atomic bomb led observers to believe that a quick "marriage" of the two would follow and inaugurate an era of "pushbutton warfare." Such estimates failed to evaluate properly the complexities attendant on the development of each device and the relatively primitive state of each.<sup>2</sup> Lacking were such factors as reliable guidance systems, competent propulsion systems, shock-resistant warheads, and the high-quality, or "clean-room," type of manufacturing facilities yet to be developed. However, early military characteristics for an air-to-ground missile had been proposed by the Army Air Force October 19, 1945, envisioning a warhead 60 inches in diameter, 130 inches long, and 11,000 pounds in weight (in obvious reference to the Fat Man bomb), although missiles capable of carrying a warhead of this size and weight would not be available for several years.

In March 1946 the Army Air Force directed the Air Materiel Command to develop an experimental missile, and this project was given a code name of MASTIFF.<sup>3</sup> At the time, little information regarding MASTIFF was made available to those working on the atomic bomb, but in one of his last actions, December 12, 1946, as head of the Manhattan Engineer District and prior to AEC assumption of control, Brig. Gen. Leslie R. Groves informed the Los Alamos Scientific Laboratory concerning the project, and stated that it envisaged installation of an atomic warhead in an air-to-ground guided missile.

This information was referred to the Z Division on January 10, 1947, with a request that preliminary analysis be made, but that any sizable amount of development work be deferred until later in the year when the work load was expected to taper off.<sup>4</sup> Subsequently, little was done on the project in either AEC or military circles beyond a general study that contemplated use of a plane-launched drone which would glide 300 miles to a target at a speed of 300 miles per hour. However, a drone with this speed was felt to be highly vulnerable to antiaircraft fire, and the existing scarcity of nuclear material, together with the inaccuracy of drone control systems, caused apprehension that an atomic weapon might be used to bomb some unoccupied field. In mid-1947, missile development for the MASTIFF project

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was assigned to Bell Aircraft Company, and was rescheduled as a long-range project to be preceded by SHRIKE, a 100-mile-range supersonic missile on which Bell had been intermittently engaged since 1945.

Subsequently, budget cuts in the 1946-1949 period reduced military participation in missile work. A 3-year period of recuperation, starting in 1950 and caused by the Korean War, partially restored financial support, but another retrenchment was made in 1953. It was not until 1956 that the missile program was consistently funded. Due to this early uncertainty, the Military gave preference to those devices which promised to reach production with the least expenditure of time and money. This generally relegated long-range missiles (which were those best suited to carrying atomic warheads) to low-priority status during the period.

The Division of Military Application notified the Military Liaison Committee, April 29, 1949, that some guided missiles being developed might reach a stage in the not too distant future where the desirability of employing them in conjunction with an atomic warhead should be considered.

This led to the establishment, June 21, 1949, of an Ad Hoc Committee, to consider the general problems of developing atomic warheads for guided missiles, and which reported to the Secretary for Defense. This Committee consisted of Lt. Gen. J. E. Hull, Director of the Air Force Weapons System Evaluation Group; Dr. F. L. Hovde, President of Purdue University; and Dr. N. E. Bradbury, Director of the Los Alamos Scientific Laboratory. This committee was to assess the possibilities for developing, within the next 5 to 10 years, guided missiles that might carry atomic warheads, and analyze the possible application of existing atomic weapons technology to the development of such warheads.<sup>5</sup>

The Ad Hoc Committee subsequently reported that Service requirements for a guided missile with an atomic warhead could be met within a reasonable time. It was concluded that four missiles could be adapted, with reasonable technical effort, to carry atomic warheads. These were the HERMES A-3 of

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Subsequently, separate conferences were held with the three Services and Sandia Base representatives of the Armed Forces Special Weapons Project. These conferences explored the details of weapon-missile relationships, placing emphasis on Mk 5 and Mk 8 Warheads.

The Sandia Weapons Development Board provided a common forum for designer and user of atomic weapons and, in a meeting June 21, 1950, agreed to accept responsibility for coordinating guided-missile and atomic-warhead development. The Board proposed that a strong missile subcommittee be formed, but temporarily deferred appointments to this subcommittee, pending arrival of new officer assignments at Sandia and Kirtland Air Force Bases.<sup>8</sup>

The Division of Military Application had noted, in a letter dated June 14, 1950, that some controversy had arisen over the subject of responsibility for warhead fuzing. Army Ordnance had assumed that the Atomic Energy Commission would handle fuze development, but the AEC felt that the fuze characteristics would be strongly affected by missile operation and environment, and therefore the fuze should be designed by the missile agency.<sup>9</sup>

This subject was discussed in the June 21, 1950, meeting of the Sandia Weapons Development Board. One proposal was that the AEC provide funds for fuze development and retain nominal control of the project, with the work being accomplished by Army Ordnance or missile contractor. The Board in general felt that the missile was simply a carrier, that it replaced the aircraft carrying bombs, and that the fuze was part of warhead development. However, it was recognized that there was no easily defined line of demarcation between warhead and missile (such as between bomb and bomber), and the eventual ruling was that a decision on fuzing design responsibility would be made for each individual missile-warhead project. The Board proposed that AEC budget for fuzing development costs in the immediate future and that these funds be allocated to the military or AEC contractor assigned responsibility for fuze development.

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On October 1, 1950, Project E, Department 1270, was established at Sandia Corporation under the jurisdiction of the Director of Engineering. The task of this Department was to study the problems of integrating atomic warheads with guided missiles. A year later, this organization evolved into Engineering II, the guided-missile Directorate.

The Division of Military Application agreed, October 10, 1950, that the AEC would accept budgetary responsibility for all guided-missile warhead fuzing with coordination of each fuze development program being subject to recommendations of the Sandia Weapons Development Board, and that requirements for an air-burst gun-type warhead were deleted.<sup>10</sup>

A Guided Missiles Committee of the Sandia Weapons Development Board was appointed and initially met October 16, 1950. The committee discussed accelerations, vibrations, and general environmental conditions which would be experienced by guided missiles, and concluded that these could be withstood by atomic warheads. The Committee proposed that a separate Ad Hoc Working Group be established for each missile-warhead marriage program, with the <sup>Group</sup> proposing technical solutions to problems encountered in the programs.<sup>11</sup> The Board approved this suggestion, and these Ad Hoc Groups became a standard and important part of the missile program.<sup>12</sup>

The Committee also felt that specific fuzing systems for guided missiles would have to be developed, but that it should be initially possible to modify bomb fuzing systems.

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It would be necessary to spell out carefully the relative priorities of the various programs, and the Committee felt that the current list of missiles should be considerably reduced in number. This list had been constantly changing, with the CORPORAL and SNARK being temporarily deleted, and additional versions of the HERMES, the RIGEL, NAVAHO, and TRITON being added.<sup>13</sup>

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involved, that of ballistic (where the missile was launched upward and then fell into a target) and that of release from a carrier downward onto a target.

The Division of Military Application notified the Military Liaison Committee, January 19, 1951, that increasing requirements for various combinations of missiles and warheads had reached the point where standardization of warhead design was becoming difficult, if not impossible, to achieve. It was felt that the design of the Mk 5 and Mk 7 Warheads had progressed to the point where these warheads could be proposed for marriage with missiles and eliminate any need for alternate warheads.<sup>16</sup>

A nomenclature system having the prefix "XW" to identify warheads under design, similar to the "TX" identification for bombs, was authorized in mid-January 1951. This prefix was followed by the warhead identification (Mark number) and was coupled with the missile designator for complete missile-warhead nomenclature. The "X" stood for experimental, and the "W" for warhead. A typical example was: XW-5/REGULUS.<sup>17</sup>

Detailed design was meanwhile proceeding on the arming system. It was felt that automatic arming should be provided, which would take place only after the missile had crossed into enemy territory, and it had been proposed that the missile guidance system be used to signal this fact. However, there was such a complexity of missiles, with different guidance systems, that this was found to be impracticable. It was possible, however, to provide a system that would sense the initial missile speed, the existence of high-enough thrust for long-enough time, the attainment of sufficient altitude, and the pursuance of the correct direction. All these factors could be gaged by gyroscopes, clocks and acceleration switches, and a system could be devised to permit nuclear insertion only when all these factors had been met or exceeded. Sandia provided such a system for all missile-warhead combinations, with the gyroscope, clock, or switch shorted out when a given missile had no need to measure that particular factor.<sup>18</sup>

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The fuze responsibility problem was again raised in the September 24, 1952, meeting of the XW-5/RASCAL Ad Hoc Working Group. Sandia and the Air Force presented opposing fuze-design proposals, and a clear-cut decision could not be reached. The problem was referred to the Guided Missiles Committee, which also could not reach unanimous decision, and it was in turn referred to the Special Weapons Development Board, where it was thoroughly discussed in a meeting November 12, 1952. The majority of the Board felt that Sandia should be assigned the fuzing task.

Meanwhile, the Air Force recommended to the Joint Chiefs of Staff that the Military be made responsible for all adaption-kit design (including that of the fuzing system) and that the interests of the AEC be confined to the design of the warhead proper. The Joint Chiefs of Staff endorsed this proposal and referred the decision through the Military Liaison Committee to the Division of Military Application. The DMA received this directive at almost the same time that it learned of the Board decision to assign the RASCAL fuzing responsibility to Sandia.

The Division of Military Application then reversed the decision of the Special Weapons Development Board, declaring, January 22, 1953, that basic responsibility for all guided-missile items of launcher, carrier, guidance, and fuzing would be assigned to the Military "... regardless of whether such parts are common to a standard rocket or missile or are required for use of the rocket or missile with a given atomic warhead."<sup>22</sup>

Subsequently, responsibilities of the Guided Missiles Committee were reviewed in the light of the above decision. It was decided to phase out this Committee and form new Joint Committees to replace the Ad Hoc Working Groups.<sup>23</sup> The major result of this change in policy was that the fuze-design responsibility was assigned to the missile contractor, who subsequently found that he could not produce fuzes with the proper capabilities within the time schedule, and who in turn subcontracted the fuze design back to Sandia.

Meanwhile, the Division of Military Application had issued a set of military characteristics September 11, 1951, covering an atomic warhead of the Mk 5 type for application to the MATADOR, REGULUS, HERMES, RASCAL, RIGEL, and

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TRITON missiles. The warhead was not to exceed 44 inches in diameter, 77-1/2 inches in length, and 3000 pounds in weight.

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Nonradiating fuzes were felt to be highly desirable, setting of burst height was to be possible just prior to missile launching, and preflight checks were to be of a simple accept or reject type.

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A variety of interpretations had previously been given to definition of warhead and warhead installation, and were standardized by the Sandia Weapons Development Board December 11, 1951. The warhead was defined as the nuclear pit and capsule, high-explosive sphere, detonators, X-unit, firing switch, nuclear insertion mechanism, and all hardware and cabling pertaining to these items. The warhead installation included the warhead, arming and fuzing system, power supply, and installation hardware. The warhead installation thus might vary for different missiles, even though the same warhead was used.<sup>25</sup>

The XW-5 Warhead would contain a Mk 5 Bomb implosion system, a Mk 5 Firing Set with a fast-firing X-unit and switch for contact bursts, and a new linear nuclear insertion mechanism.<sup>26</sup> Mk 5 nuclear capsules would be

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used. This would produce a warhead 44 inches in diameter and 75-1/2 inches in length with a weight of 2550 pounds, excluding power supply, arming and fuzing, and mounting hardware.<sup>27</sup>

The Sandia Weapons Development Board ruled that the warhead installation should not be design released until six successful tests of the warhead in the missile had been made. Missile availability dates were still largely indefinite, but it was felt that at least 9 months would be required between design release and early production.

The Mk 5 Mod 0 Warhead was design released August 1953, and production was achieved July 1954. The warhead incorporated a linear nuclear insertion mechanism, but otherwise was identical with the Mk 5 Bomb less outer case.

A Mk 5 Mod 1 Warhead was proposed for use with the RASCAL missile, incorporating dual-motor nuclear insertion mechanism, but was canceled during design, April 16, 1956.<sup>28</sup>

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Investigation was undertaken of both forward extending pressure probes and trailing devices. It was hoped to develop a simple barometric fuze, but tests showed that the pressure pickups did not give reproducible results, and that the missile would have to travel faster than Mach 1.0 to prevent premature fuze operation.<sup>32</sup> A decision was made to use a baro-armed radar fuze, a modification of the fuze design of the Mk 5 Bomb.<sup>33</sup>

In early 1952 the Mk 5/REGULUS was given a higher priority than its Mk 8 counterpart, since there was a limitation in the number of missiles available for test flights.<sup>34</sup> Work was started on a contact fuze for several missiles, and successful completion of this task made it possible to provide the XW-5/REGULUS with two fuzing options; radar air burst with contact-fuze backup, and surface burst by impact crystals.

The Navy had requested that a pure barometric fuze be developed, and this was discussed in the June 27, 1952, meeting of the Ad Hoc Working Group. Sandia reported that this design would require an additional 10 months, and that it was not at all certain that such fuze would have the required accuracy. The Group, after considerable discussion, decided to approve the radar fuze for use in the REGULUS and to continue development of a barometric fuze.

The RAM Program (for REGULUS Assault Missile) was initiated by a letter from the Military Liaison Committee to the Division of Military Application August 18, 1952. This was a project to provide the capability for launching the REGULUS missile from a surface ship, guiding the missile to target, and arming and detonating the warhead by command from carrier-based fighter aircraft.<sup>35</sup>

The program was given a high priority in mid-February 1953, and a small number of Mk 5 Bombs were placed in standby storage April 1953, together with the hardware to convert these bombs to RAM installation, which had been renamed the REGULUS Interim Capability Program. These units were subsequently retired in mid-1954, as normal XW-5/REGULUS components became available.<sup>36</sup>

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The launching action closed two pullout switches which applied power to the timer motors. At the end of 6 minutes' safe-separation time, the timer made power available. If the command arming signal bypass switch was closed, the nuclear capsule was now inserted; otherwise, receipt of the command nuclear-arm signal resulted in this operation. When the missile "dump" signal was received, voltage was made available to relays controlled by an arming baroswitch. In addition, these arming relays connected the radar arm circuits to the fuze baroswitch.

When the missile descended to a pressure altitude of about 20,000 feet, the arming baroswitch closed, starting the inverters and charging the X-unit. At an altitude 700 feet higher than the desired height of burst, the fuze baroswitch closed and armed the radars, which began transmitting and receiving. If both radars were operating properly, the X-unit was triggered and caused detonation when the second of the two radars ranged. If one radar failed to range at its preset altitude, detonation occurred 300 feet lower, when the fourth element in the fuze baroswitch closed. This element effectively switched the radar firing lines from a series to a parallel connection. If both radars failed to operate, an impact-fuze system triggered the X-unit.

For the RAM mission, special plugs were installed which allowed the X-unit to be charged when a command electrical arm signal was received from the control aircraft. Transmission of a second command caused the nuclear insertion mechanism to operate, and subsequent issuance of the command-fire signal detonated the warhead. The impact fuze provided a backup.

Meanwhile work had been proceeding on a barometric fuze design. Some progress was made and, in the Ad Hoc Working Group meeting October 7, 1953, it was decided that the remaining REGULUS flight-test missiles would be used to prove out this system, which had been given the designation XW-5/RG-X1. Authorization for this modification was issued subsequently by the AEC and design release scheduled for June 1954.

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A new high-speed missile, the REGULUS II, was being developed. This would travel at twice the speed of the original REGULUS, or about Mach 2.0, and this increased velocity would more than double the ability of the missile to penetrate enemy defenses without being shot down. Test vehicles of the new design would be available by the fall of 1955, and a feasibility study was authorized by the Secretary of Defense December 1953.<sup>38</sup> The REGULUS II program was promoted to full-scale development stage in April 1955.<sup>39</sup>

Tests of the pressure-sensing system for the XW-5/RG-X1 showed that

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This, however, required additional missile flights, and the design release date was postponed to January 1955.

On August 19, 1954, the Military Liaison Committee proposed that responsibility for REGULUS adaption kits be transferred to the Navy. A meeting was held October 28, 1954, at which it was decided that this transfer would be made July 1, 1955.<sup>40</sup>

A production-model REGULUS, carrying a Mk 5 Warhead, was launched from the cruiser Los Angeles February 15, 1955, with the missile flight being controlled by an accompanying aircraft. Inflight insertion and command arming were accomplished satisfactorily, although the flight came to an abrupt termination when the warhead was accidentally detonated just short of the target. However, missile and warhead performance were satisfactory throughout the 23-minute flight, which covered 173 miles.<sup>41</sup>

Evaluation flights from submarines were largely successful. Impact tests indicated that the contact crystals generated sufficient voltage to detonate the warhead, and that this detonation occurred prior to warhead deformation. Impacts produced by travel through rain or hail, however, would not cause premature detonation. Thus, the system was given general release.

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It had been suggested that the design with the barometric fuze be identified as a Mod change upon entry into stockpile. Action on this suggestion, however, was tabled pending assumption of design control by the Navy. Subsequently, it was decided that the Mk 5 Warhead would be replaced by the Mk 27, and all Sandia activity was suspended on the Mk 5/REGULUS Warhead Installation March 1, 1956.<sup>42</sup>

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### CHAPTER III

#### MK 5/MATADOR WARHEAD

The MATADOR was a surface-to-surface, turbojet-powered, transonic missile with a range of about 600 nautical miles. The missile was constructed in the shape of a streamlined fighter plane with an over-all length of 39 feet, maximum diameter of slightly over 4 feet, and swept-back wings. It was launched from a zero-length launcher by a single, solid-propellant rocket, which accelerated the missile until the turbojet engine could attain enough thrust to sustain flight. This rocket booster was pneumatically ejected at time of burnout.

At launch, the missile climbed to an altitude of 40,000 feet, then followed a level trajectory to a "dump point" where it pushed over and dove into the target. Two guidance systems were proposed for use, Shanicle and Marc. Shanicle used four ground stations, which generated guidance beams. The missile received these signals and converted them into azimuth and range guidance. Marc used two trailers that tracked the missile and sent command signals. When the "dive point" was reached with either system, the missile followed a programmed terminal trajectory to the target. MATADOR was designed and built by the Glenn L. Martin Company for the Air Force.

The missile was initially considered for marriage with an XW-5 atomic warhead in early 1950.<sup>43</sup> The MATADOR project was accelerated in late 1950, due to the situation in Korea, and on December 18, 1950, the Joint Chiefs of Staff recommended to the Secretary of Defense that a number of missile projects be approved, among them the MATADOR.<sup>44</sup>

Much of 1951 was taken up with consideration of the solution of general problems relating to the development of atomic warheads for guided missiles, and it was not until October 3, 1951, that an XW-5/MATADOR Ad Hoc Working Group was named by the Guided Missiles Committee and held its first meeting. The Group proposed that both radiating and nonradiating fuzes be considered,

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but that--due to program urgency--the TX-5 bomb radar fuze be initially used. Several methods for warhead arming were proposed. One approach would use a clock timer in conjunction with the missile's gyro compass, and another design would incorporate command arming, using the missile's command guidance system. The first of these was felt to be the more reliable.

These recommendations were considered in the December 11, 1951, meeting of the Sandia Weapons Development Board. The Air Force would be responsible for determination of the data upon which the decision to arm or not to arm would be based, and for supplying a suitable signal to the warhead; and Sandia would be responsible for applying this signal to cause arming.<sup>45</sup>

The Division of Military Application wrote to the Military Liaison Committee February 4, 1952. Design release of the Mk 5/MATADOR warhead installation could not be made before February 1953, to allow sufficient time for six systems flight tests, and production would require another year. The Department of Defense, however, had authorized substantial production of the missile for early 1952, and it thus appeared as though the nuclear warheads would lag the missile by about a year.<sup>46</sup> A request was made that the Mk 5/MATADOR program be expedited, but there appeared to be no way in which this schedule could be shortened.

Detailed consideration of the design in early 1952 resulted in a system that would use a timer which furnished an arming signal after the missile had crossed over into enemy territory. The guidance system would put the missile into a terminal dive if it deviated from its course. If the arming timer did not operate, no nuclear detonation would take place.

A trailing probe was tested to signal burst height by barometric means. However, this device had a number of disadvantages, including problems of storage and release after missile launch, time lag of operation, the fact that only one probe could be installed in the space available, and assembly

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had been reduced in weight, and a linear nuclear insertion mechanism installed. This mechanism could be operated either by command signal or arming timer.

A heading-error device built into the missile would cause it to enter a terminal dive, should the missile flight path stray more than certain specified limits from a preset course. An acceleration switch would operate 1 second after missile launch and close a safety switch. After the arming signal was received, a "dump" signal from the missile guidance system would start the fuzing sequence and initiate the terminal dive to the target. When the missile reached a point in the dive where external pressure was equal to one-half sea-level atmosphere, the X-arm baro would close, starting two inverters and charging the firing set. At a preset lower altitude, the fuzing baro would close, placing the two radars in operating condition. These two radars would initially be connected in series, and both would have to "range" (or operate) to detonate the bomb. Slightly below the desired burst altitude, these radars would be reconnected in parallel, so that operation of either radar would detonate the bomb. The impact fuze was not yet available, but was under development, and it was hoped to incorporate it in the Mod 0.

Meanwhile, missile production difficulties were being encountered. Early missile flight tests were also unsuccessful, with the arm signal failing to operate on the first flight; the missile breaking up in the terminal dive in the second; and the missile being destroyed in the third, when it became impossible to correct a severe deviation from the planned flight path. The design-release date was postponed to June 1953.

Three flights were made during March 1953, but all were unsatisfactory from the warhead standpoint, primarily due to missile failure. The AEC stated that it appeared undesirable to continue to divert Mk 5 high-explosive components from current production for use in MATADOR flights until the missile problems were solved and, as a result, further missile flights were postponed.<sup>51</sup>

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After missile modifications were made, successful flights were made in August 1953, and warhead installation flights were resumed September 1953.<sup>52</sup> A MATADOR missile with a Mk 5 Warhead was launched from the Air Force Missile Test Center in Florida November 2, 1953. It accepted no commands after takeoff, and was eventually destroyed by removing all carrier guidance and allowing the missile to dive out of control. Reports of a crash in the Bahamas led to recovery of parts of the missile, but the warhead components were never located.<sup>53</sup>

In spite of the lack of flight-test verification, an interim release of the Mk 5/MATADOR warhead installation was made January 1954, and Report SC2982(TR), Interim Design Status Report of the XW-5/B-61A MATADOR, was approved by the Special Weapons Development Board. Additional missile difficulties then developed, and it appeared as though the final release could not be made for several months.<sup>54</sup>

On February 24, 1954, the Air Force Special Weapons Center requested Sandia to provide a barometric fuze for the Mk 5/MATADOR.<sup>55</sup> However, by this time the Military had assumed responsibility for design of new fuzing systems, and this problem was referred to the Air Force, with Sandia services as subcontractor being offered.<sup>56</sup>

Operation BLACK SWAN was established in the spring of 1954. This was a MATADOR Interim Capability Program under which bomb-to-warhead conversion components were supplied on an expedited basis, and associated with five Mk 5 Bombs for use in the event of national emergency.<sup>57</sup> These items were retained for possible use until late 1954.

Report SC3344(TR), Description and Status Report at Design Release of the XW-5/B-61A Atomic Warhead Installation, was presented to the June 30, 1954, meeting of the Special Weapons Development Board.<sup>58</sup> This report was accepted, after some revisions were made to the premature figures, and transmitted to the Division of Military Application. The Final Evaluation of the Mk 5/TM-61A

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Atomic Warhead Installation, SC3560(TR), was also reviewed by the Board, July 13, 1955. ]

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The warhead, although not being truly a universal design, incorporated many components from other weapons.<sup>59</sup>

Some small effort was made to incorporate an XW-5-X1 Warhead containing the barometric fuze being developed by the Air Force. However, these plans were eventually dropped, and all effort ceased on the Mk 5/MATADOR project in early 1956.<sup>60</sup>

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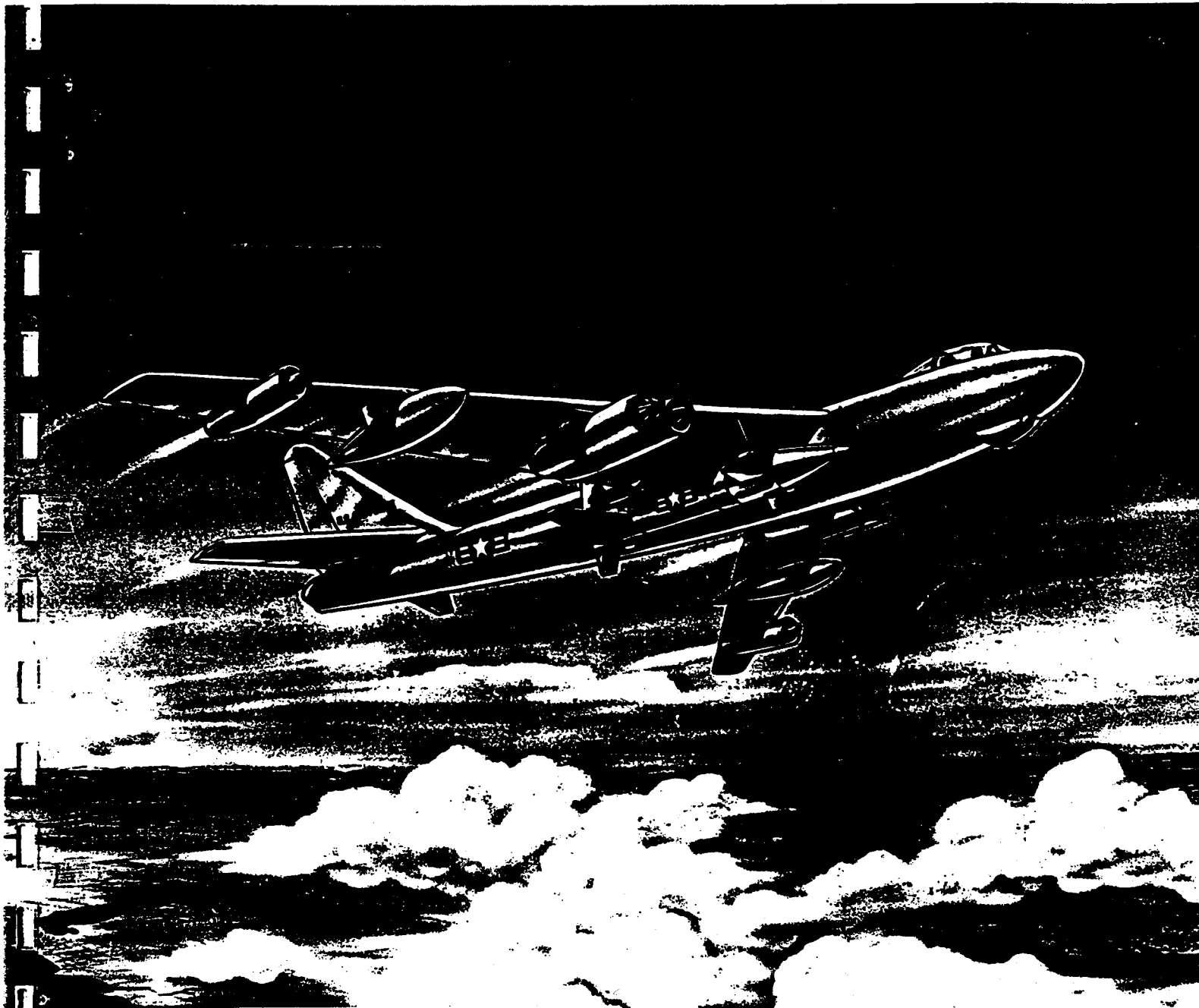


Figure 4. RASCAL Missile

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By early 1952 the design release of the warhead installation was scheduled for July 1954, early production a year later, and stockpiling by October 1955.<sup>63</sup> Shortly thereafter, it was felt that the program could be accelerated by about a year, due to the similarity of the design to the one already considered for the MATADOR missile.<sup>64</sup> The chief carriers of the missile-warhead would be the B-36 and B-47 Air Force bombers. The weapon would be carried in the rear bomb bay of the B-36, and on a pylon under the wing of the B-47.

It was proposed that Sandia design and provide the initial fuze, with a low-altitude fuze study being conducted by both Sandia and Bell Aircraft. Details of the Sandia fuzing system were discussed in the September 24, 1952, meeting of the Ad Hoc Working Group. Sandia advocated the use of a radar system, noting that jamming of these radars would be difficult and expensive. The Military desired a nonemanating fuze, and felt that the system should be of this type. Sandia agreed to develop both systems, with emphasis on a baro-fuze approach.<sup>65</sup>

The Military then proposed that the entire arming and fuzing task be assigned to the Air Force, since they felt that this system and the missile were closely interrelated.<sup>66</sup> This proposal was approved by a majority of the Group and referred, through the Guided Missiles Committee, to the Special Weapons Development Board.<sup>67</sup> The Board agreed that it would be desirable to develop a barometric fuze, since the shallow glide angle of the RASCAL compounded radar problems, but the majority of the Board felt that Sandia should develop the fuze.

The problem was then referred to the Division of Military Application, as noted in Chapter I, and final decision made to assign fuzing responsibility to the Air Force. The problem was turned over to the Bell Aircraft Company, which somewhat reluctantly issued subcontracts to various barometric-switch manufacturers for the development of suitable devices.

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replied that the Air Force still desired a RASCAL capability with the XW-5 Warhead, and that Mk 5 flight tests were now scheduled for the period January through September 1956, while missiles configured to carry the XW-27 would not be available until October 1956.<sup>72</sup>

However, further study and negotiation resulted in cancellation of the Mk 5/RASCAL program in March 1956. A quantity of components and hardware to convert Mk 5 Bombs to XW-5-X1/RASCAL warhead installations was retained for a temporary period for possible combat use.<sup>73</sup>

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CHAPTER V

MISCELLANEOUS MISSILES

RIGEL

Field Command notified Sandia August 28, 1950, that the Navy was planning to incorporate a Mk 5 Warhead into the RIGEL guided missile.<sup>74</sup> Information regarding this missile was requested from its contractor, the Grumman Aircraft Engineering Corporation, during a missile conference held at Sandia Base September 27-28, 1950. The Navy requested that provisions be made for the RIGEL to carry either the Mk 5, Mk 7 or Mk 8 Warhead.

Field Command pointed out to Sandia, in a letter dated November 29, 1950, that design of the RIGEL contemplated boosted launch from a short-rail launcher. The booster rockets would accelerate the missile from rest to approximately Mach 1.7 in about 4 seconds, after which the boosters would be jettisoned and the ramjet engines would further accelerate the missile to a cruising speed of Mach 2. During the boost phase, the longitudinal acceleration would be as high as 17 g's, and it appeared possible that accelerations of 20 g's might be experienced for short periods of time.<sup>75</sup>

The Mk 5 Warhead could withstand accelerations of 8 to 10 g's, but reduction of RIGEL launch accelerations to this level would require a major program, involving several years of research into composition and burning rates of propellants. Since the prototype warhead for the RIGEL would not be needed until 1954, it was hoped that a rugged implosion-type warhead might be developed by that time, and a request was made that Sandia make preliminary study of a Mk 5 implosion design that could withstand longitudinal accelerations of 20 g's.

A set of detailed missile characteristics was furnished to Sandia April 25, 1951.<sup>76</sup> This described the RIGEL as a supersonic, submarine-to-surface,

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bombardment missile with a maximum diameter of 45 inches, a length of over 45 feet, and able to carry a warhead weight of 3000 pounds.

After launch, the missile would climb to a cruising altitude of 50,000 feet and fly to an "area of influence" of guidance stations, where mid-course guidance would be provided. This system was a modified Loran type, using two submerged submarines as control stations. The missile would interrogate the submarines and fly along a hyperbolic path established by these replies. The replies were timed so that the missile path would pass through a target release point. At this point the missile would automatically push over into either a programmed ballistic or homing path to the target. The first tactical missile firing was planned for November 1952, initial firing from a submarine in November 1954, and Fleet evaluation in December 1955.

Little subsequent work was done, however, and, September 30, 1953, the Division of Military Application notified Santa Fe Operations Office that the RIGEL program had been canceled and that requirements for an atomic warhead installation for this missile had been withdrawn.<sup>77</sup>

#### HERMES

The Sandia Weapons Development Board was notified March 13, 1951, that the Army was developing proximity fuzes for use with the HERMES missile carrying a conventional warhead. It was noted that the military characteristics for these fuzes were similar to those of atomic weapons, except for the higher reliability required in atomic weapons. Inasmuch as this increase in reliability could be achieved by using multiple fuzing, it was suggested that the Board make formal assignment of this project to the Army.<sup>78</sup>

On May 21, 1951, the Division of Military Application sent a teletype to Sandia, stating that the HERMES missile had been deleted from the marriage program, and that the Sandia program should be adjusted accordingly.<sup>79</sup> The

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Military Liaison Committee notified the Division of Military Application on June 4, 1951, that the missile had been formally removed from the list of approved weapons projects, but that it had been added to the list of guided-missile test vehicles.<sup>80</sup>

Meetings were held in late 1951, to discuss the possibilities of reinstating the Mk 5 Warhead into the HERMES, so that a missile warhead-compartment design could be produced that would be compatible with Sandia's handling equipment. By May 27, 1952, schedules were being firmed up. Static tests would start April 1953, and flight tests July 1953. The missile operational date would be late 1954, with full production by early 1956. Operational suitability tests of the Mk 5 Warhead in the HERMES missile were planned for mid-1954.<sup>81</sup> General Electric Company, contractor for the HERMES missile, proposed that Sandia enter the project January 1954, by which date the third missile would be available for use.

Sandia was assigned design responsibility for the nose cone, which would have to be pressurized during flight to prevent electrical breakdown of the components. Some difficulty was anticipated with sealing problems, since the ring on which the nose cone was mounted did not lend itself readily to such designs. Sandia suggested, in a letter to Field Command June 9, 1952, that the nose cone be redesigned by the missile contractor, since it was closely associated with the missile airframe design.<sup>82</sup>

Sandia notified the Sandia Field Office of the AEC, June 11, 1952, that conferences with the missile contractor had determined that systems tests could start no earlier than October 1953. Design release would be accomplished by March 1954.<sup>83</sup>

Sandia wrote to Field Command September 25, 1952, stating that nose cones would be furnished for test flights of all HERMES missiles. These would contain inert warheads and Sandia-designed fuzes. It appeared that either a barometrically armed radar fuze or a pure barometric fuze would be used, but it was stated that design responsibility for the fuze had not been formally assigned.

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On October 16, 1952, Field Command stated that, due to budget cuts, the HERMES program would be delayed about 6 months.<sup>84</sup> Thus, no current action would be taken on the formation of an Ad Hoc Working Group.<sup>85</sup>

Fiscal funds were still lacking by August 25, 1953.<sup>86</sup> On September 18, 1953, the Military Liaison Committee notified the Division of Military Application that the Army had terminated the development of the HERMES missile as an operational weapon, and that the requirement for an atomic warhead installation for this missile was accordingly withdrawn.<sup>87</sup>

F-101

On April 9, 1953, the Division of Military Application notified Santa Fe Operations Office that the Joint Chiefs of Staff had established a military requirement for development of a streamlined case to enable a supersonic fighter-type aircraft to externally carry the Mk 5 Bomb. Initial application was to be made to F-101 aircraft, and it was considered desirable that the Air Force proceed with the development of the case and the associated non-nuclear components.<sup>88</sup>

A study was made by Wright Air Development Center, after which the Air Force directed McDonnell Aircraft Corporation to develop an externally carried case, named Store 96. This Store was a symmetrical shape 394 inches long and with a maximum diameter of 44 inches. It had three tail fins, with the lower fin retractable to provide ground clearance for loading the weapon and for takeoffs and landings. Gross weight of the shape, including the Mk 5 Warhead and 849 gallons of fuel, was 9240 pounds. The fuel would be expended by the aircraft en route to the target, and, at release, with all fuel expended, the Store would weigh 3776 pounds. The weapon could be released from the carrying aircraft by low-altitude bombing release, M-1 bombing computing system, or by dive bombing, with optical sighting. An ejector mechanism would assist to separate the bomb from the airplane at release.

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By fall 1953, the design had progressed to the point where initial test flights could be undertaken by mid-1954 and operational capability could be achieved by January 1956. Early flight tests would be made in B-47 bombers, with 15 drops being made to check out weapon stability and barometric sensing. A subsequent test series would check the fuzing and firing system, and separation under varying conditions.<sup>89</sup>

An XW-5/F-101 Joint Project Group was formed August 1953 to coordinate activities of the Armed Forces Special Weapons Project, the Air Force Special Weapons Center, and Sandia in the shape 96 project.<sup>90</sup> By the July 20, 1954, meeting of the Group, it had been decided to use a radar-timer-contact fuze, and to discard a baro-timer-contact design that had also been considered.<sup>91</sup>

On April 26, 1955, AEC notified Sandia that thermonuclear warheads should be considered for application to the Shape 96. Sandia would provide an appropriate arming and fuzing system.<sup>92</sup> Some thought was given to the application of a Mk 15 Warhead, but this proposal was deleted.<sup>93</sup> In March 1956 the Air Research and Development Command canceled the applications of both the Mk 5 and Mk 27 programs to the F-101, as flight tests had demonstrated fairing problems causing buffeting.<sup>94</sup> Attempts were made to solve these problems; but the program had been delayed to the point that other, and better, weapon combinations became available.<sup>95</sup>

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Glossary of Mk 5 Warhead Terms

Air Force Special Weapons Center -- That element of the Air Force Systems Command having to do with compatibility testing of nuclear devices with aircraft. Located at Kirtland Air Force Base, Albuquerque, New Mexico.

Armed Forces Special Weapons Project -- An interdepartment agency formed to handle military functions related to atomic weapons.

Barometric Fuze -- Fuze incorporating a baroswitch. A pressure device actuated by increasing air pressure as the warhead descends in its trajectory.

Capsule -- The nuclear <sup>element</sup> capsule of an atomic weapon which, when subjected to compression in the implosion process, becomes supercritical and produces a nuclear reaction.

Cartridge -- An assembly, generally containing fuzing and firing system elements, which can be inserted and removed from an atomic weapon in the manner of a cartridge being inserted or removed from the chamber of a rifle.

Contact Fuze -- A fuze that detonates the weapon by contact with the ground or the target.

Department of Defense -- The Armed Forces, i.e., the Army, Navy and Air Force.

Detonators -- <sup>Explosive devices which when initiated by the fuze ignite the charge of the high explosive sphere,</sup> ~~Devices containing bridge wires which, when subjected to an electrical lead, burn rapidly and act as a match to apply a flame to various points on the outer surface of the high explosive sphere.~~

Division of Military Application -- An AEC office that functions as liaison between the Military and weapon designers and producers.

Dump -- The point in its trajectory at which a guided missile "dump<sup>A</sup>" or turns toward the target.

Fat Man Bomb -- The implosion device used during World War II in the attack on Nagasaki. So-called due to its bulging contour.

Field Command -- The local office of the Armed Forces Special Weapons Project, located on Sandia Base, Albuquerque, New Mexico.

Fuze -- A combination of the arming and firing devices of a weapon.

g -- Force equal to one unit gravity.

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*provided with appropriate lens change to correct the exposure*  
Implosion -- The effect created when a sphere of high explosive is detonated on its exterior surface. The force of the exploding wave is directed largely toward the center of the sphere.

Jato -- Named for Jet-Assisted Take-Off. A jet device initially designed to assist heavily loaded aircraft to take off from short runways. Used as a boosting device in missile launching.

*A group composed of the Chief of Staff of the*  
Joint Chiefs of Staff -- ~~An Army-Navy-Air Force group~~ to determine policy and to develop joint strategic objectives of the Armed Forces.

Kiloton -- A means of measuring the yield of an atomic device by comparing its output with the effect of an explosion of TNT. A 1-kiloton yield is equivalent to the detonation effect of 1000 tons of high explosive.

Los Alamos Scientific Laboratory -- A nuclear design organization located at Los Alamos, New Mexico.

Mach -- A measure of speed. Mach 1.0 is the speed of sound, or 738 miles per hour at sea level.

Mark 27 -- A relatively small and light thermonuclear weapon, developed both as bomb and warhead.

Military Liaison Committee -- A Department of Defense Committee established by the Atomic Energy Act to advise and consult with the AEC on all matters relating to military applications of atomic energy.

Nautical Mile -- A naval measurement of length. One nautical mile is equivalent to 6076.1033 feet, or the length of 1 minute of arc (1/21,600) of a great circle of the earth.

Prototype -- An early weapon type, generally hand-produced before a production run.

Proximity Fuze -- A fuze that detonates the weapon as soon as it comes within a certain specified distance of the ground or target.

*hollow metal shell*  
Pit -- The ~~space~~ at the center of an implosion bomb, *which receives* The nuclear capsule is inserted into this space.

Radar -- Named for Radio Detecting and Ranging. Radars emit a pulse of high-frequency energy and measure the time lapse from that transmission to receipt of a reflected electrical "echo" from an object. This time measurement determines the distance of the object from the transmitting antenna of the radar.

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Sandia Weapons Development Board -- A joint Sandia-Military board at Sandia Base to provide local guidance on weapons design.

Santa Fe Operations Office -- The local office of the Atomic Energy Commission (AEC) concerned with the operations of Sandia Corporation.

Special Weapons Development Board -- Change of name for the Sandia Weapons Development Board, effective May 14, 1952.

Subsonic -- Any speed below that of Mach 1.0, which is the speed of sound, or 738 miles per hour at sea level.

Supersonic -- Any speed exceeding that of Mach 1.0.

Telemetry -- The transmission of signals from a moving object.

Thermonuclear -- Two-stage reaction, with a fission device exploding and starting a fusion reaction in light elements.

X-Unit -- ~~A high voltage transformer.~~

*A device used to provide high voltage to the weapon detonator.*

XW-8 -- A gun-type weapon, designed for target penetration.

Z Division -- A division of the Los Alamos Scientific Laboratory, elements of which moved to Sandia Base and became the nucleus of Sandia Laboratory.

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